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SEQUENTIAL EVALUATION OF PROBLEM-SOLVING PROCESSES.

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QUESTION-STUDY AS A METHOD FOR INTERPRETING AND MEASURING PROBLEM-SOLVING BEHAVIOR WAS STUDIED. DATA WERE OBTAINED FROM A PREVIOUS STUDY (ED 003 005) AND ANALYZED. ANALYSES WERE PERFORMED TO DETERMINE WHETHER QUESTIONS WERE MORE USEFUL FOR ASSESSING PROBLEM-SOLVING BEHAVIOR THAN ANALYSIS OF SOLUTIONS. TECHNIQUES, FORMULAE, AND RESULTS PERTINENT TO USING QUESTION-STUDY FOR ASSESSING PROBLEM-SOLVING PROCESSES WERE ILLUSTRATED. DATA AVAILABLE FOR THIS STUDY PERMITTED ONLY A PARTIAL EXAMINATION OF THE PROBLEM. IT WAS INDICATED THAT VALIDATION OF THE METHOD WOULD REQUIRE A FORMAL EXPERIMENTAL APPROACH. THE STUDY INDICATED THAT THE LENGTH OF QUESTION SEQUENCES SHOULD ALSO BE INVESTIGATED. (WN)

ED003006

CR 1015
Part II

PSYCHOMETRIC LABORATORY

SEQUENTIAL EVALUATION OF PROBLEM SOLVING PROCESSES

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by

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SEQUENTIAL EVALUATION OF PROBLEM SOLVING PROCESSES *

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Understanding the processes that mediate between stimulus and response has been a major concern of psychological theory and practice in areas such as personality, intelligence, creativity and so forth. The study of these processes has relied heavily on the analysis of the characteristics of the responses following the application of stimuli. A variety of constructs have been developed in order to explain the "gap" between stimulus and response.

The response in itself may be considered to be the final step of the process that begins with a certain stimulation. This response may not have a unique relationship with the preceeding process. It has not been demonstrated experimentally that all similar responses result from similar processes or that the same stimuli are followed by the same processes. Yet this seems to be the assumption often followed in the interpretation of responses. When analyzing test results, incorrect responses are usually considered to be equally wrong, or responses are assigned to predefined categories without considering the preceeding processes. Similar assumptions are used in relation to the correct responses. For instance the assumption that in multiple choice situations errors may all be considered equally wrong does not seem to have a solid justification (Simmel, 1957, Rimoldi, 1945), but the acceptance of this viewpoint has been widespread in practical and theoretical situations. This oversimplification eliminates individual differences by ignoring the process that leads from the stimulus to the response and casts doubts about the reasonableness of the conclusions reached. "In summary, the study of the responses is not enough to establish

the veracity of the inferences that can be made about the process." (Rimoldi, 1961b).

A considerable amount of information is lost when complex processes are reduced to simple stimulus response situations. For instance, in a problem solving situation a subject in reaching for a solution may try various approaches and obtain different amounts of information. The type of information received may stimulate the subject to continue with some particular types of approach, to reject others, or to adopt new methods of procedure. This process continues until the subject reaches a solution, or until he exhausts all possibilities or gives up. (Rimoldi, Devane, 1961). From this viewpoint the process begins when the problem is presented. The subject then actively seeks out additional information that may eventually lead him to a correct or an incorrect solution.

Sometimes in interpreting psychological data it has been assumed that human beings behave according to some mathematical or other type of models. But things may be more complex and more challenging than this. Stevens (1957) and Chapanis (1961) have pointed out the dangers and limitations that a strict adherence to models may introduce in psychology. Further, psychological measurements may be at times too refined for the type of data that is usually available. In the last issue we have observations. Many of these are crude and others slightly more refined. Their interpretation is not necessarily facilitated by introducing mathematical transformations or by trying to fit them into preconceived models.

If rather than concentrating exclusively on the development of models and then going to the experiment to appraise their success, phenomena are examined, experiments performed, and appropriate methods are

developed or applied to deal with the situations as they arise, then the chances of solving some problems may increase.

In the present study attempts will be made to describe a method that aims to study psychological processes rather than products (Bloom & Broder, 1950; Rimoldi, 1955), considering that some psychological problems may be clarified by the experimental study of the processes that mediate between stimulus and response.

One of the attempts made in order to clarify this problem led to the development of a psychological technique that has been described in several articles (Rimoldi, 1955, 1960, 1961a, and 1961b). It consists essentially in studying the questions that a subject asks in order to solve a problem. After each question the subject receives the information* requested until he reaches what he considers to be the solution (Rimoldi, 1955).

In one type of experimental condition, the experimenter prepares a set of possible questions. These questions are written on cards that contain the corresponding information on the reverse side. The subject chooses (asks) those questions that he thinks will help him in solving the problem. By asking a question the subject, as it were, selects the stimuli that he desires among those available to him (Rimoldi, 1955). The experimenter controls the information provided after each question as well as the total number of questions that the subject may ask.

In another type of approach the subject himself "invents" the questions he wants to ask and the experimenter provides the answer. This second type of approach is more difficult to control experimentally, though

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* Information is not used here in a technical sense.

nearer to actual problem situations outside a laboratory environment. The differences between those two approaches have been described elsewhere (Rimoldi, 1961b). Both of them are only approximations to real situations and aim at studying individual processes in terms of the sequence of questions asked.

The technique has been used for the evaluation of medical students and physicians (Devane, Rimoldi, Haley, 1960; Haley, 1960), performance of members of clinical teams (Mohrbacher, 1960), Rorschach diagnosis (Tabor, 1959), personality dynamics (Gunn, 1962) and thought processes (Rimoldi, Devane, 1961). It can be extended to other areas as well. The development of the problem solving information apparatus (R. John, 1957; R. John & Rimoldi, 1955) is another application of the technique to the study of problem solving of a complex nature, under restricted conditions.

A process is experimentally characterized by the sequence of questions asked by the subject. Any characterization of the process should include at least number of choices made, type of choices and their order. The same question may have an entirely different meaning according to the questions previously asked. It is assumed that at every successive step the problem changes, and that what the subject knows and what he may still want to know is not a fixed property of the problem but varies as the solution develops.

To assume that subjects will follow a rigid sequence of questions (tactics) may be a serious handicap in interpreting their performance since it denies the possibility of adapting behavior to changing circumstances. It may be postulated that changes in the perception and interpretation of

the task will give rise to new clues, hunches and new approaches which will lead to a new understanding and redefinition of the problem. The objective exploration of differences in these areas may help to understand better the concepts of creativity and talent, and to complement usual psychological techniques.

Another important aspect of the study of processes is the identification of those questions that were not asked. Although this may be implied in the number, type, and order of choices made, a more direct analysis may be illuminating. When evaluating an individual it is important to know what he does not do as well as what he does. Then individuals can be compared or evaluated not only in terms of those steps that they consider useful but also in terms of steps which they think are unnecessary in reaching a solution.

Scoring Methods

Early attempts at characterizing performance have been published already. (Rimoldi, 1955; Rimoldi & Grib, 1960a, 1960b; Rimoldi, Devane, & Haley, 1961). One way of evaluating results employed the concept of "utility index" defined as a ratio between the frequency with which a given question was selected by the members of a group and the total number of subjects in the group. This procedure does not consider the order in which a question is chosen, though this seems to be one of the crucial aspects in the interpretation of performance. With pattern analysis (Grib & Rimoldi, 1960a, 1960b) this limitation was partially overcome.

The method presented here is a more successful attempt in this direction, since it includes in the evaluation of a question its frequency

of choice at a given position in the sequence. The general framework of the method will be illustrated by the presentation of a theoretical case. An extension of the method that also considers the frequency with which questions are not selected will be used to discuss a real case.

Table I presents the frequency with which the five possible questions of a problem have been chosen by a group of 100 subjects in any of the five possible orders. In this example non selections will not be considered.

Table I

Frequencies of Questions Asked
in Each Order for a Theoretical Case

		Questions					
		a	b	c	d	e	Total
Order	1st	4	8	51	10	27	100
	2nd	12	17	8	52	10	99
	3rd	5	53	5	24	4	91
	4th	3	8	4	7	3	25
	5th	2	1	1	5	1	10
	Total	26	87	69	98	45	325

The proportions corresponding to the frequencies of Table I are presented in Table II. These proportions can be used to describe any individual in terms of the group to which he belongs. They can also be used as norms for scoring other individuals not belonging to the group. The distinction must be made whether the proportions are used for descriptive purposes or as norms for scoring independent observations. In either

case an individual is scored by adding the corresponding values as they occur in his sequence.

Table II

Observed Proportions of Questions Asked in Each Order for a Theoretical Case

		Questions					
		a	b	c	d	e	Total
	1st	.012	.025	.157	.031	.083	.308
	2nd	.037	.052	.025	.159	.031	.304
Order	3rd	.015	.163	.015	.074	.012	.280
	4th	.009	.025	.012	.022	.009	.077
	5th	.006	.003	.003	.016	.003	.031
	Total	.080	.268	.212	.302	.138	1.000

Subject A who selected questions d, b, c in this order accumulates .031 + .052 + .015 = .098, and subject B who selected the same questions in order c, d, and b accumulates .157 + .159 + .163 = .479. In Figure 1 the performance curves obtained by accumulating these values are represented by a solid line. The differences between these curves as a whole and at each successive step are very striking. It is clear that the introduction of order in characterizing a question has added an important feature in the representation of the processes of each individual.

The observed performance curves can be interpreted in terms of reference values that represent either other observed performances or special hypotheses concerning the particular problem under examination. In Table III the proportion to be expected under the assumption of no

association between questions and order are given. This hypothesis is used here only for the purpose of demonstration, rather than in order to verify a point. As a matter of fact the hypothesis of no association may not be strictly appropriate for interpretation purposes when using this technique.

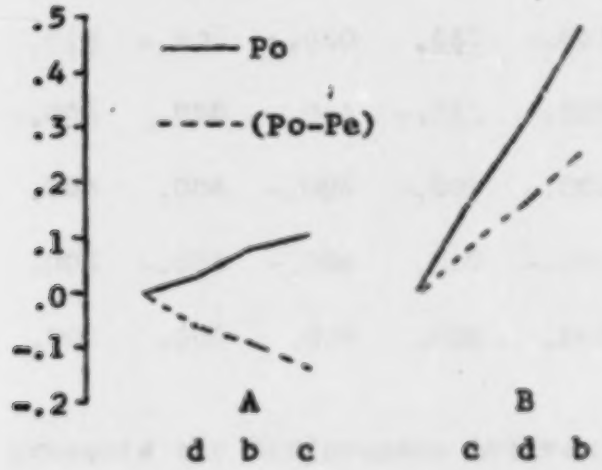

Figure 1. Observed and Observed Minus Expected Performance Curves of Two Tactics for the Hypothetical Case.

Table III

Expected Proportions of Questions Asked in Each Order for a Theoretical Case

		Questions					
		a	b	c	d	e	Total
Order	1st	.025	.083	.065	.093	.042	.308
	2nd	.024	.081	.065	.092	.042	.305
	3rd	.022	.075	.059	.085	.039	.280
	4th	.006	.021	.016	.023	.011	.077
	5th	.003	.008	.007	.009	.004	.031
	Total	.080	.268	.212	.302	.138	1.000

Table IV

Observed Minus Expected Proportions of Questions Asked in Each Order for a Theoretical Case

		Questions					
		a	b	c	d	e	Total
Order	1st	-.013	-.058	.092	-.062	.041	.000
	2nd	.013	-.029	-.040	.067	-.011	.000
	3rd	-.006	.088	-.044	-.011	-.027	.000
	4th	.003	.004	-.004	-.001	-.002	.000
	5th	.003	-.005	-.004	.007	-.001	.000
	Total	.000	.000	.000	.000	.000	.000

Table IV presents the differences between observed and expected proportions in terms of the reference values presented in Table III. If the observed proportions agree with the expected, the difference score would be around zero. The further the observed values deviate in either direction from the reference values (expected), the greater the difference score becomes.

The summation of differences between observed and expected proportions (Po-Pe) for subject A who followed the sequence d, b, c gives (-.062) + (-.029) + (-.044) = -.135. Subject B who selected questions c, d, and b in that order receives a difference score of (.092) + (.067) + (.088) = .247. These values are indicated in Figure 1 by broken lines and show how at every step subjects A and B deviate from the expected performance.

For a problem with n possible choices the total number of possible

tactics can be computed by using the formula:

$$\sum_{i=1}^{n} \frac{n!}{(n-i)!}$$ i = number of choices in a given tactic

In the present example, since the test has five possible choices, the total number of possible tactics is 325. Each one of these can be represented graphically by means of performance curves as already indicated.

Table V

Values for Some of the Tactics in the Theoretical Case

No. of Tactic	Sequence	Sum of Observed Proportions	Sum of Observed Minus Expected Proportions
1	a	.012	-.013
261	e	.083	.041
131	c	.157	.092
149	cab	.357	.193
166	cdba	.488	.250
169	cdbea	.494	.248
109	bdcea	.214	-.034
202	dbcea	.113	-.134
201	dbce	.107	-.137
224	dce	.068	-.129
94	bce	.062	-.125
66	b	.025	-.058
218	dcbea	.234	-.013
235	dac	.083	-.093

A summary statement can be obtained for every subject by adding the proportions corresponding to the choices made according to his tactic. Similarly every tactic can be represented by accumulating the values of the observed minus expected proportions. In Table V values for some of the tactics are presented.

By plotting the total sum of the observed proportions against the total of the observed minus expected proportions for all possible tactics, polygonal convex sets are obtained. In the present case the convex set contains 325 tactics. Figure 2 shows only the limits of this convex set and some of the tactics. The values presented in Table V correspond to the corners of the convex set given in Figure 2, with the exception of tactics 235 and 218. Notice that tactics 218 and 169 differ only in the order in which the first two questions were asked; that tactics 218 and 1 have equal values for observed minus expected proportions; and that tactics 235 and 261 have equal values for the sum of the observed proportions. Inspection of Figure 2 and Table V shows changes in the composition of tactics as the boundary of the convex set is followed. This suggests that families of tactics may be studied. The relationship between convex sets using reference values computed from different hypotheses may also be examined, and used for interpretation purposes.

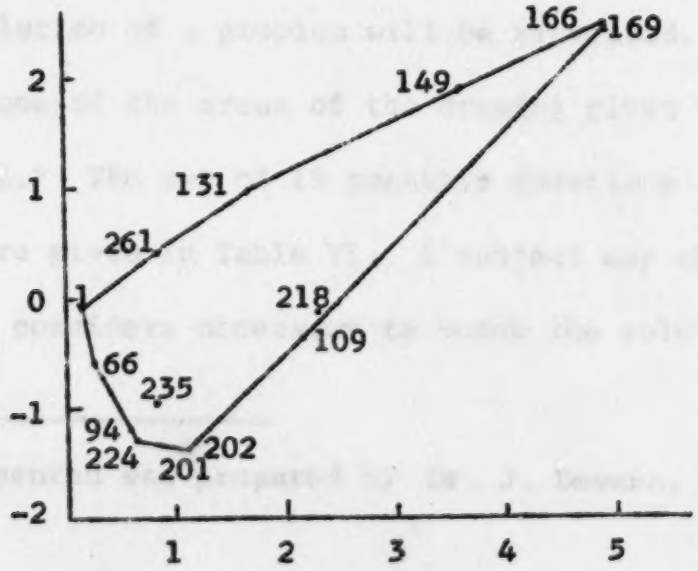

Figure 2. Convex Set for the Hypothetical Case.

In the example given, the proportions derived from Table I do not represent norms obtained from an independent sample. Thus the operations performed using these values are essentially descriptions of performance of the subjects in terms of their own group. But if independent norms are used then the performance curve of each subject can be interpreted in terms of these norms. According to the nature of the problem each subject's tactic can be scored in terms of one or more norms and the corresponding performance curves can be directly compared.

An individual's performance can also be analyzed in terms of his agreement with reference values by subtracting the corresponding reference values from the observed values. The reference values may represent a statistical hypothesis, or what should be expected in terms of a psychological theory, or results obtained experimentally. For the same observed performance curve different observed minus expected curves can be obtained, if several hypotheses are tested. This provides a useful method for the comparison of different hypotheses and to suggest which hypothesis fits the observations best.

Application and Discussion of the Method

In this section the results obtained by a group of 25 college students in the solution of a problem will be presented. Subjects were asked to identify one of the areas of the drawing given in Figure 3. The selected area was E.* The set of 19 possible questions and the corresponding answers are given in Table VI. A subject may choose among these questions those he considers necessary to reach the solution of the problem.

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* The problem presented was prepared by Dr. J. Devane.

Table VI

Questions Employed in Problem IV
and Corresponding Answers

	Question		Answer
1.	Is it in exactly four figures?	1.	No, it is not in exactly four figures.
2.	Is it in exactly three figures?	2.	Yes, it is in exactly three figures.
3.	Is it in exactly two figures?	3.	No, it is not in exactly two figures.
4.	Is it in only one figure?	4.	No, it is not in only one figure.
5.	Is it in the largest triangle?	5.	Yes, it is in the largest triangle.
6.	Is it in the larger rectangle?	6.	Yes, it is in the larger rectangle.
7.	Is it in the smaller rectangle?	7.	No, it is not in the smaller rectangle.
8.	Does it have exactly four straight sides?	8.	No, it does not have exactly four straight sides.
9.	Does it have exactly three straight sides?	9.	No, it does not have exactly three straight sides.
10.	Does it have exactly two straight sides?	10.	Yes, it does have exactly two straight sides.
11.	Does it have exactly one straight side?	11.	No, it does not have exactly one straight side.
12.	Is it in the left hand side of the figure?	12.	Yes, it is in the left hand side of the figure.
13.	Is it in the right hand side of the figure?	13.	No, it is not in the right hand side of the figure.
14.	Is it in the larger circle?	14.	No, it is not in the larger circle.
15.	Is it in the smaller circle?	15.	Yes, it is in the smaller circle.
16.	Does it have a curved border?	16.	Yes, it does have a curved border.
17.	Is it in a rectangle?	17.	Yes, it is in a rectangle.
18.	Is it in a circle?	18.	Yes, it is in a circle.
19.	Does it have a right angle?	19.	No, it does not have a right angle.

Figure 3. The Drawing Used for Problem IV.

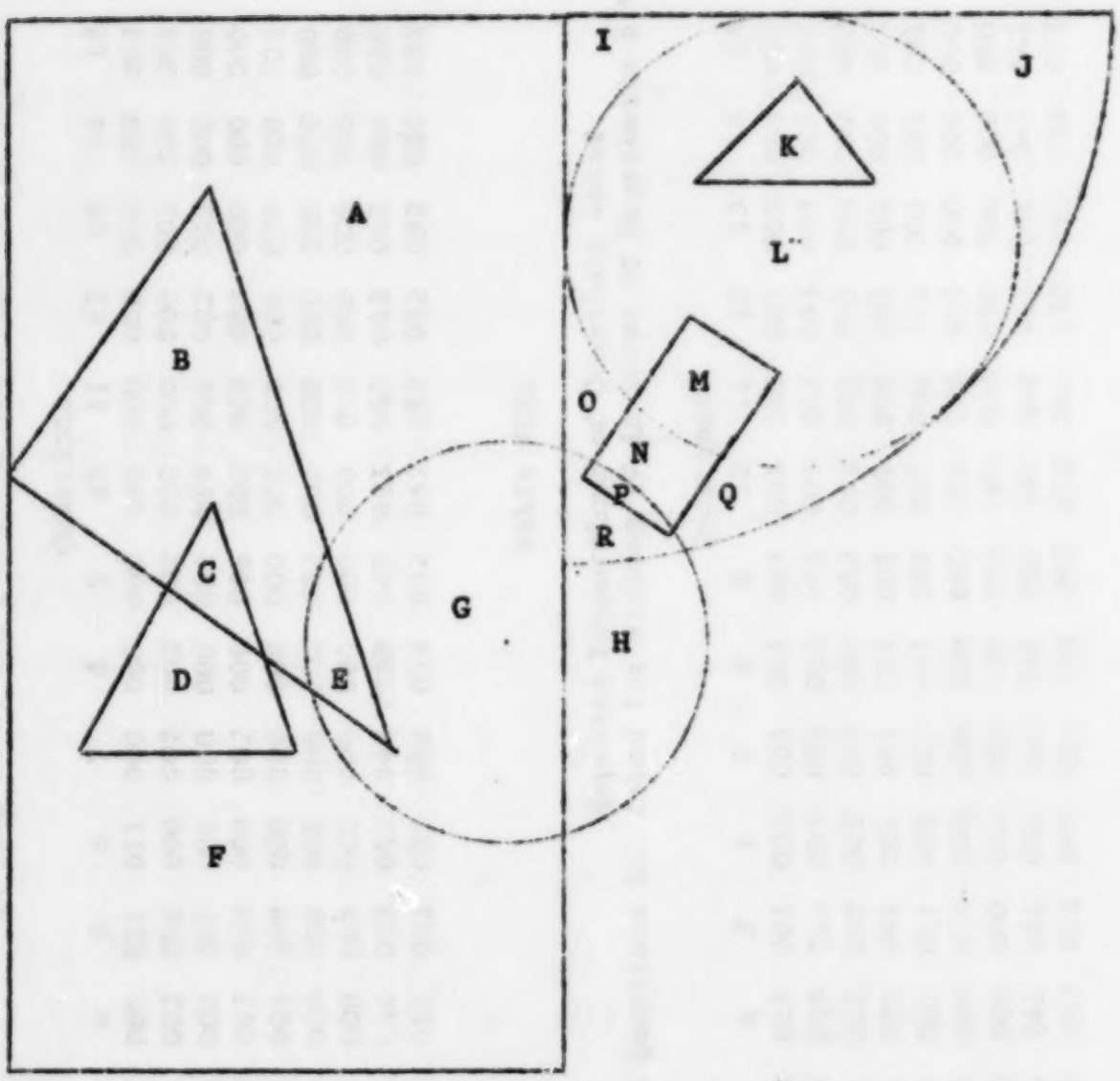

Table VII

Observed Proportions of Questions Asked
in Each Order and Questions Not Asked for Problem IV *

	Questions																		
Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Σ
1	000	002	002	000	011	011	000	000	000	000	000	006	000	000	002	006	004	006	002	052
2	000	000	000	002	006	000	002	002	002	000	000	000	002	006	004	015	002	002	006	051
3	000	002	000	002	002	000	000	000	002	019	004	002	002	000	000	004	000	004	002	045
4	000	000	000	002	002	000	002	000	006	002	006	002	000	000	000	002	004	000	000	028
5	002	002	002	000	000	000	000	000	000	006	000	000	000	000	002	004	000	000	000	018
6	000	002	000	000	000	000	000	000	002	002	000	000	000	000	000	002	000	000	000	008
7	000	000	000	000	000	000	000	000	000	000	002	000	000	000	000	000	000	000	000	002
0	050	044	048	046	032	042	048	050	040	023	040	042	048	046	044	019	042	040	042	786
Σ	052	052	052	052	053	053	052	052	052	052	052	052	052	052	052	052	052	052	052	99

Table VIII

Expected Proportions of Questions Asked
and Questions Not Asked for Problem IV in Terms of Hypothesis b *

	Questions																		
Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Σ
1	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	052
2	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	003	051
3	002	002	002	002	002	002	002	002	002	002	002	002	002	002	002	002	002	002	002	045
4	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	028
5	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	001	018
6	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	008
7	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	000	002
0	041	041	041	041	041	041	041	041	041	041	041	041	041	041	041	041	041	041	041	786
Σ	052	052	052	052	052	052	052	052	052	052	052	052	052	052	052	052	052	052	052	

* Discrepancies between cell values and sum is due to rounding errors
Decimal points have been omitted for all entries

The performance of each subject will be characterized by the questions that he does not ask as well as by those that he asks. The observed proportions are presented in Table VII. The proportions corresponding to the number of times that a question was not selected is indicated as 0 order. Since no subject asked for more than seven questions, the observed order of selection varies from 1 to 7.

Two major hypotheses have been used to obtain the reference proportions: a) propbrtions expected in terms of combinatorial theory, assuming that any question can be selected in any order and b) proportions expected in terms of the observed marginals for both questions and order of selection. These values are given in Table VIII. Under hypothesis a the expected proportion of any item being selected in any of the first seven orders is, for this problem, .003. The manner in which these values are determined will be presented by Rimoldi and Georgas (1962) in a future publication.

Previous observations (Rimoldi, 1956) have shown that the more frequently selected questions tend to occur at a particular point in the sequence. In Figure 4 performance curves for subjects 11, 13, 14, and 24 are presented. Curves a and b represent the observed minus expected proportions for hypotheses a and b respectively. The sequences followed by each subject are: 6, 16, 10 for subject 11; 2, 17, 11, 12 for subject 13; 16, 19, 13, 4, 1, 9, 11, for subject 14; and 17, 16, 9, 11, 3, 2, for subject 24.

The final answer says little about the process; for instance, subjects 11 and 14 solved the problems correctly while 13 and 24 failed.

Examining the corresponding graphs it would be difficult to develop a rationale to relate the same type of answer to the different tactics.

Of the four subjects presented, 11 obtained the highest possible value at each successive step. His observed minus expected performance curves show a considerable departure from the 0 line. Subject 13's observed minus expected performance curves also deviate from the 0 line but in the opposite direction. The values accumulated by subject 14 do not change after the second question in terms of the observed performance and in terms of hypothesis b, the change is negligible. Under hypothesis a, subject 14 deviates in a negative direction. With the exception of the second question subject 24 shows only slight changes in all his curves.

A subject will show a rapidly rising observed performance curve, whenever he agrees with the group. Also his general performance may differ from the group and still show a rapid increase at one or more steps because at this moment he performs according to the group.

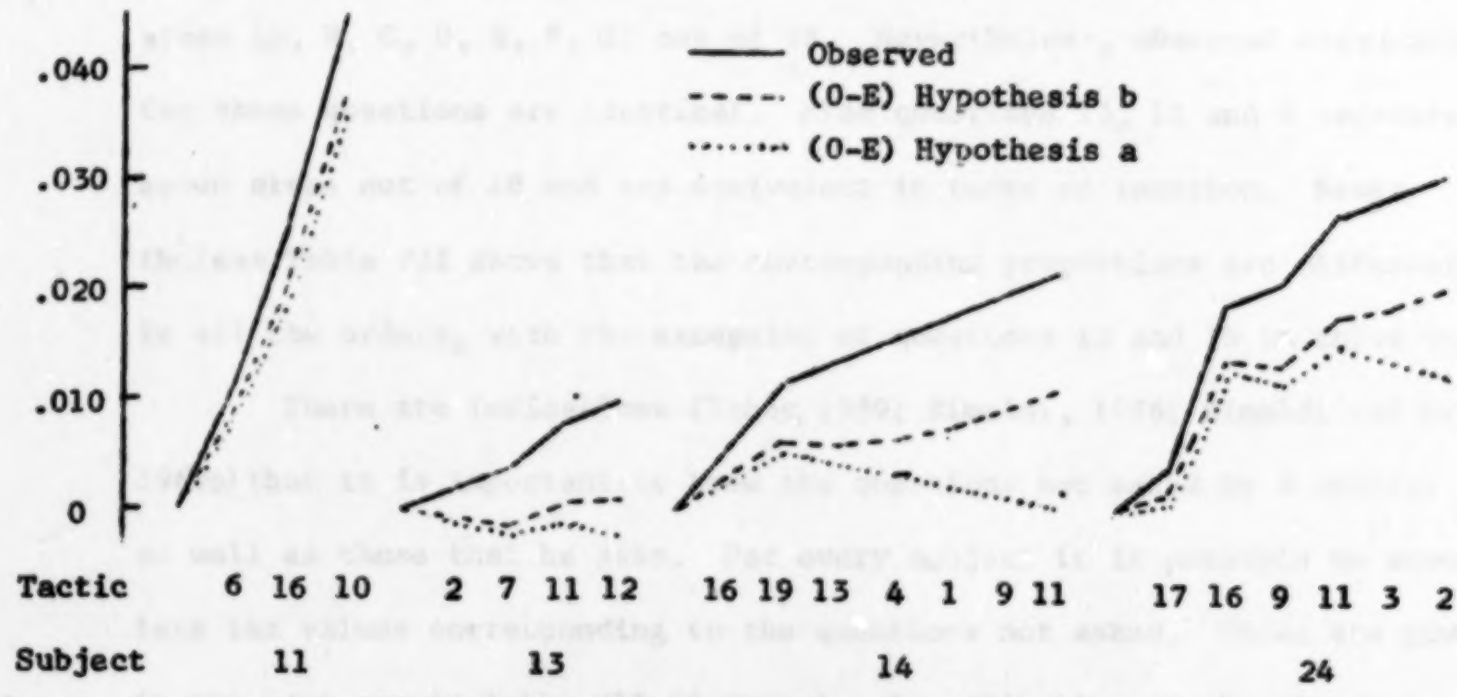

Figure 4. Observed and Observed Minus Expected Performance Curves of Four Subjects Who Took Problem IV.

Some subjects show a unique type of observed performance curve. This in itself is not an indication that they did poorly but rather that they performed differently than the group. This may be due either to superior ability or to lack of ability, and could be used to identify original thinking. For instance a subject showing a unique performance curve may show rapidly rising curves when scored in terms of a group of highly selected talent.

The desire to analyze performance in terms of tactics that are more economic, less complex, or whatever approach may appeal to an experimenter, would require a new operation. This would consist essentially of building a table of expected proportions based on the desired reference values. For example, a table can be built in terms of possibilities eliminated by each question, and this compared with the observed performance. For instance, question 5 isolates three possible areas (B, C, and E) out of the 18 areas in the figure, while question 6 isolates seven possible areas (A, B, C, D, E, F, G) out of 18. Nevertheless, observed frequencies for these questions are identical. Also questions 13, 12 and 6 separate seven areas out of 18 and are equivalent in terms of location. Nevertheless Table VII shows that the corresponding proportions are different in all the orders, with the exception of questions 12 and 13 in third order.

There are indications (Tabor, 1959; Rimoldi, 1956; Rimoldi and Grib, 1960a) that it is important to know the questions not asked by a subject as well as those that he asks. For every subject it is possible to accumulate the values corresponding to the questions not asked. These are given in the last row in Table VII (0 Order). An estimation of the observed

values for items not selected can be made for each subject by adding the corresponding observed values for the 0 order. Subtracting from these the corresponding values at the 0 order, calculated in terms of the reference values, and adding them, a total value is secured. This value can be interpreted as an overall departure from the hypothesis under examination. The results are given for each one of the 25 subjects in columns 2, 3, and 4 of Table IX. The same table also presents the results obtained by accumulating the observed values of the questions asked and the observed minus expected in terms of the two hypotheses. The corresponding polygonal convex sets are given in Figures 5, 6, and 7.

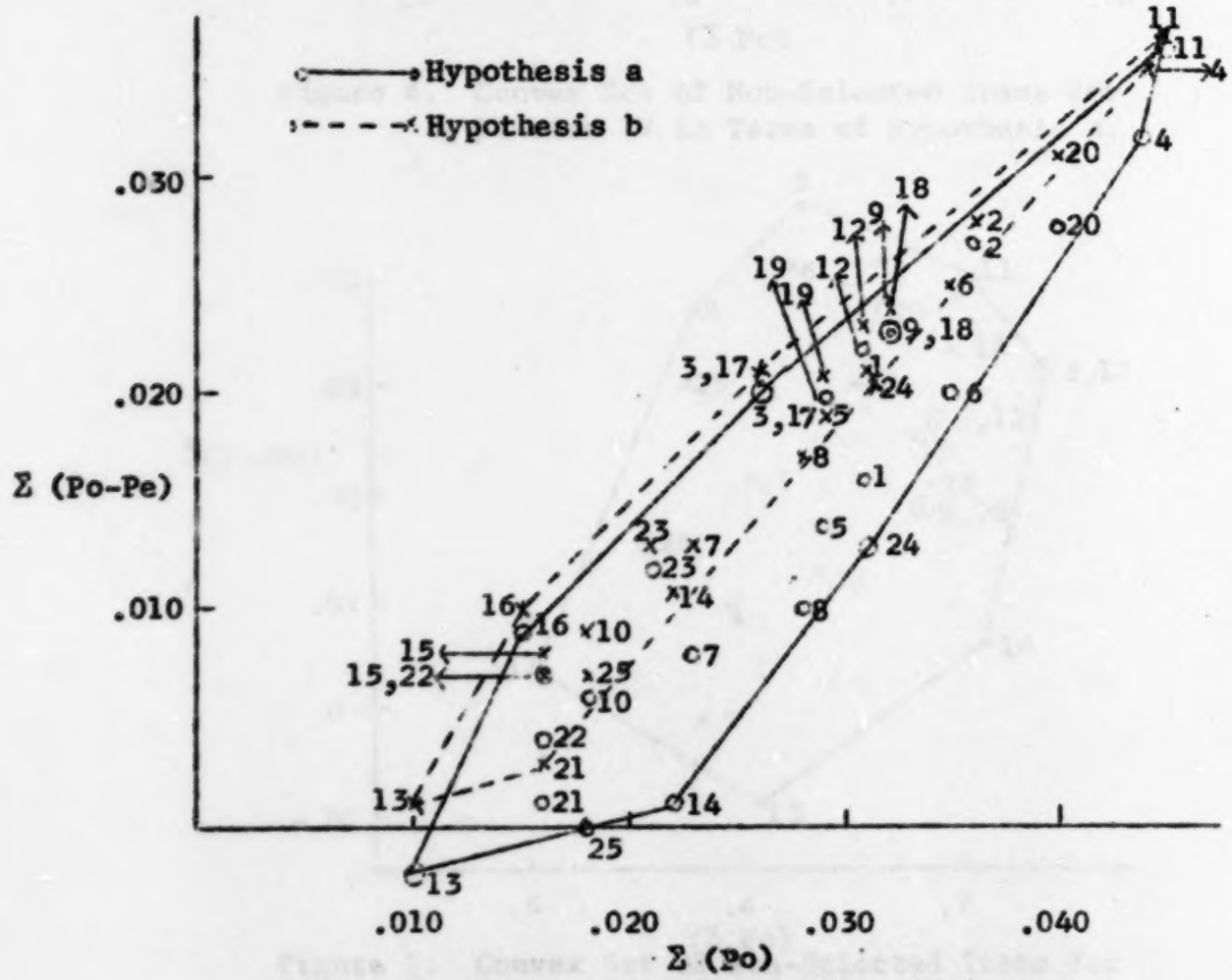

Figure 5. Convex Sets for Problem IV in Terms of the Two Hypotheses Studied

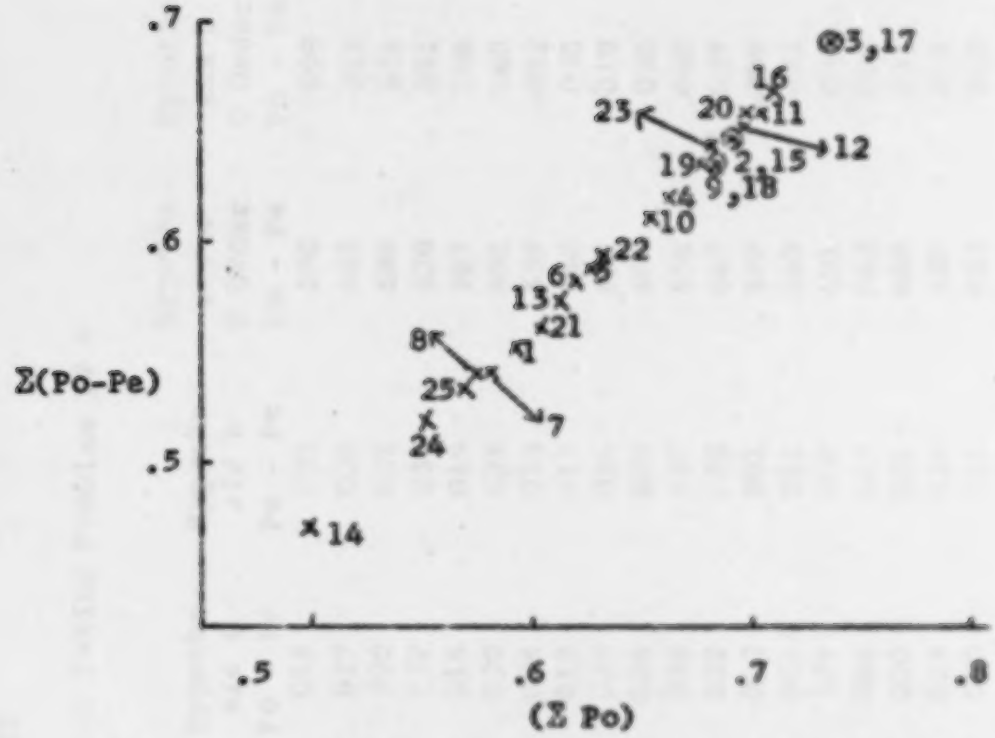

Figure 6. Convex Set of Non-Selected Items for Problem IV in Terms of Hypothesis a.

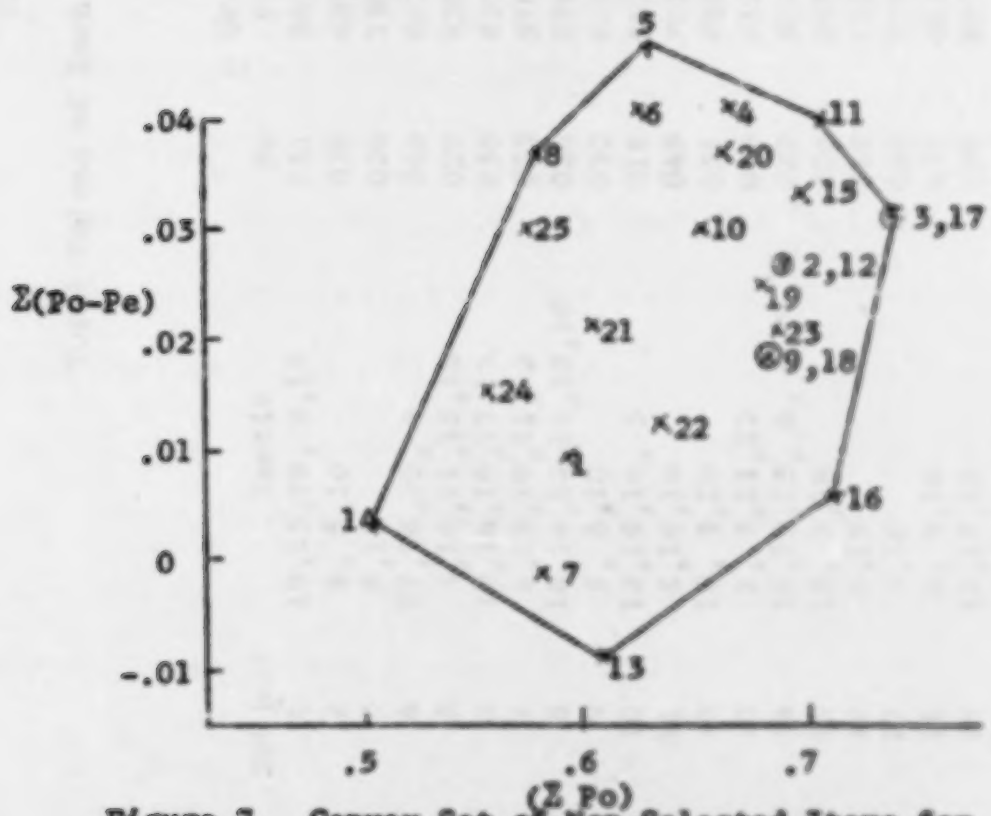

Figure 7. Convex Set of Non-Selected Items for Problem IV in Terms of Hypothesis b.

Table IX

Total Values of Each Subject Taking Problem IV *

Subject	Tactic	Po	0 Order Po	Hypothesis a Po - Pe	Hypothesis b Po - Pe	Hypothesis a 0 Order Po - Pe	Hypothesis b 0 Order Po - Pe
1	19,13,10, 9,15	031	589	016	021	550	009
2	6, 5,10	036	689	027	028	645	027
3	5,16	026	735	020	021	688	031
4	17,16,10, 9	044	662	032	035	620	041
5	5,14,11,16,10	029	626	014	019	587	046
6	12,16,18,17,10	035	620	020	025	581	040
7	6,18,19,11, 2	023	578	008	013	539	-002
8	18,14,12,11,10,16	028	576	010	017	540	038
9	5, 8,10	032	681	023	024	637	019
10	12,19,16, 5	018	651	006	009	609	030
11	6,16,10	045	702	036	037	658	040
12	16, 5,10	031	689	022	023	645	027
13	2, 7,11,12	010	612	-002	001	570	-009
14	16,19,13, 4, 1, 9,11	022	501	001	011	468	004
15	16, 5,18	016	695	007	008	651	033
16	5,15	015	710	009	010	663	006
17	5,16	026	735	020	021	668	031
18	6, 9,10	032	681	023	024	637	019
19	12,15,10	029	677	020	021	633	005
20	15,16,10,17	040	695	028	031	653	037
21	3, 4, 5, 9,16	016	601	001	003	562	021
22	18,14, 2,10	016	633	004	007	591	012
23	6,19,16	021	603	012	013	639	021
24	17,16, 9,11, 3, 2	031	553	013	020	517	015
25	18,17, 4, 7,16,10	018	568	000	007	532	030

* Decimal points have been omitted for all entries

Notice that certain tactics, for instance, 11 and 16 show little or no displacement under the two hypotheses, while others like 5 and 14 show greater changes. The possibility of interpreting psychologically the extent of the displacements in terms of hypotheses is currently being investigated.

The two convex sets in Figure 5 have different areas and their boundaries have different slopes and intercepts. For instance, the slope of the line connecting tactics 13 and 16 is different in the two sets and the same tactics do not necessarily have the same relation with the boundaries of the set, or among themselves under the two hypotheses. The possibility that for the same set of observations different hypotheses will generate polygonal convex sets with different number of sides may be also of interest to understand the relationships and structure of the hypotheses in terms of the observation.

Analyzing tactics 12 and 24, it is seen that in terms of observed proportions they are identical but that they become differentiated as soon as we try to interpret them in terms of the two hypotheses. Similarly though tactics 6 and 3 have the same values in terms of observed minus expected proportions under hypothesis a they show different observed values. The relationship between these tactics is also different under hypothesis b. Using the observations as invariant the properties of the hypotheses can be compared and identified.

Performance can be also analyzed in terms of the convex sets for the non-selected questions. Let us compare tactics 14 and 16 under the two hypotheses. In terms of non-selections and for hypothesis a, observed

minus expected values are almost at the opposite ends (Figure 6) but in terms of selections made (Figure 5) they are much closer. Similarly, if the convex set for non-selections under hypothesis b is taken into consideration (Figure 7) it is possible to see that tactics 14 and 16 have almost the same observed minus expected value. That is, two similar tactics, not identical in terms of questions asked, may be different in terms of questions not asked and this will depend on the hypotheses tested.

The development of this method had one basic purpose, i.e., to help to interpret psychological processes and to obtain cues for future experimentation. This was only partially attempted in this paper in the examination of the problem described and no interpretation of the thought processes involved has been made. A final validation of the method still requires a formal experimental approach to indicate its worth. Notice that in determining the proportion of times that a given question was selected in a given order the length of the sequence in which it occurs has been ignored. This refinement may be introduced in further developments of the techniques. At the present time work is being performed to establish levels of significance for this technique.

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